WIRING MATTERS

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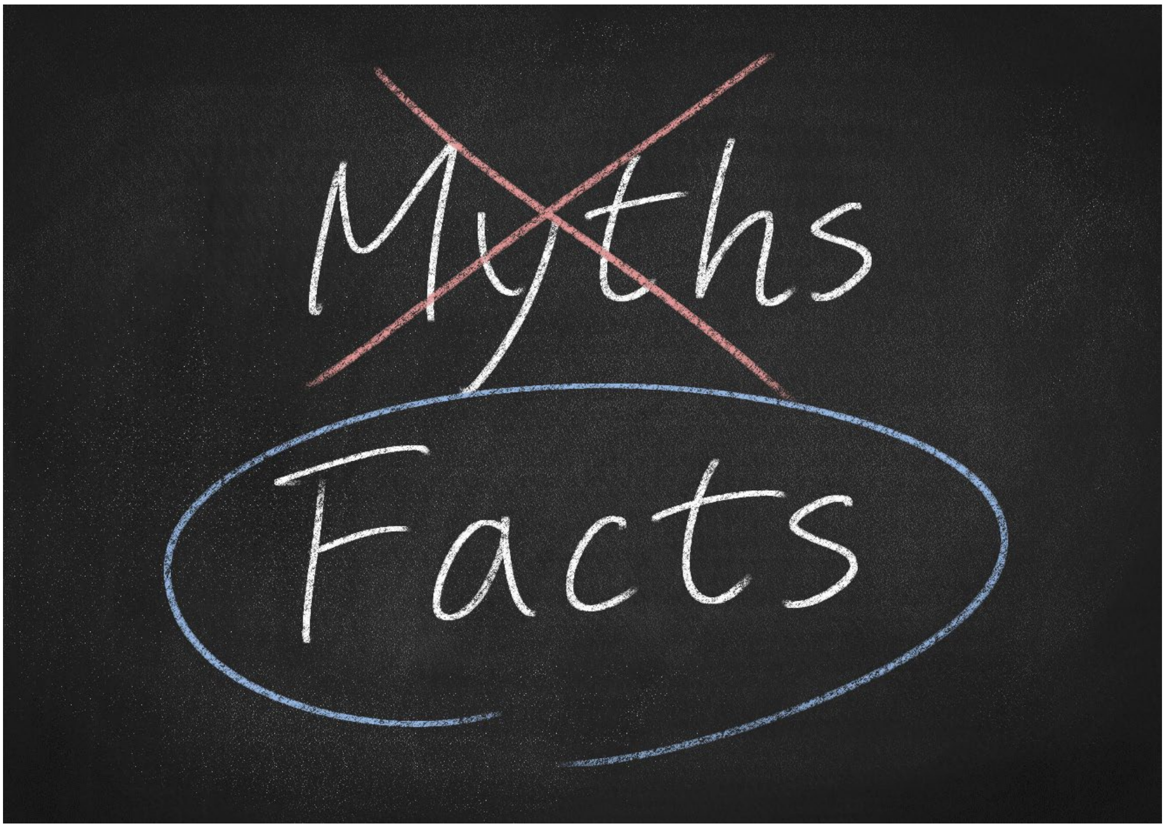


Mythbusters #8: “Socket-outlets must be protected by a 30 mA RCD.”

By: **James Eade**

Mythbusters returns to cover socket-outlets, this time regarding 30 mA RCDs.

Well, as this is a myth buster column, there are no prizes for guessing that this statement is not actually true. While many circuits do require such protection, it is also very common to find (for example) sockets-outlets to BS EN 60309 (also known as ‘commando’, ‘industrial’ or ‘ceeform’ depending on what industry you work in) with quite high ratings such as 63 A or even 125 A protected as such.

One can understand the rationale perhaps used by a designer – it is a socket-outlet for mobile equipment, extension leads etc. which may get damaged and pose a risk. Therefore a 30 mA RCD is a logical choice to provide suitable protection. Or is it?

The first question is to consider what the load(s) actually are. Most readers would struggle to come up with many *single* items of current using equipment rated at over 32 A that are mobile and designed to connect to such supplies. Generally, the larger supplies often are used to power a distribution circuit such as that in a mobile unit, temporary distribution board or a distribution unit in a 19” rack housing IT equipment, for example. These will often have 30 mA protection already fitted to the final circuits.

BS 7671:2018+A2:2022 introduced changes to the requirements for socket-outlets as follows:

***411.3.3** Additional requirements for socket-outlets and for the supply of mobile equipment for use outdoors*
In AC systems, additional protection by means of an RCD with a rated residual operating current not exceeding 30 mA shall be provided for:
socket-outlets with a rated current not exceeding 32 A in locations where they are liable to be used by persons of capability BA1, BA3 or children (BA2, BA3),
socket-outlets with a rated current not exceeding 32 A in other locations, and
mobile equipment with a rated current not exceeding 32 A for use outdoors.

An exception to (ii) but not (i) or (iii) is permitted where a suitably documented risk assessment undertaken with the involvement of a skilled person (electrically) determines that RCD protection is not necessary.
NOTE 1: For the purpose of this exception, an ordinary person (BA1) instructed in the use of the installation does not become an instructed person (electrically) or cease to be an ordinary person.
The documented risk assessment shall be provided with the appropriate electrical installation certificate.
The requirements of Regulation 411.3.3 do not apply to FELV systems according to Regulation 411.7 or reduced low voltage systems according to Regulation 411.8.
NOTE 2: See also Regulations 314.1(iv) and 531.3.2 concerning the avoidance of unwanted tripping.
NOTE 3: RCD protection of all socket-outlets is recommended.
NOTE 4: See Appendix 2, item 11 in respect of risk assessment.
NOTE 5: A lighting distribution unit complying with BS 5733, shaver supply unit complying with BS EN 61558-2-5, luminaire track system, installation coupler, LSC or DCL is not regarded as a socket-outlet for the purposes of this regulation.

It should be noted that this requirement does not apply to socket-outlets rated at more than 32 A. Neither is there a distinction between single and three-phase supplies.

Let’s consider the individual indents. The first (i) requires protection for users who are ordinary, unskilled people (BA1), young (BA2) or disabled (BA3), which is a reasonable requirement. The second point (ii) is where many socket-outlets might fall – a common example being a 32 A BE EN 60309 connector providing power to a server rack in an IT room.

The paragraph below indent (iii) does allow a risk assessment option for socket-outlets not used by those falling into categories BA1, BA2 or BA3. This may be appropriate in installations such as the IT room example where such a location is typically under skilled supervision by technicians and the risk of damage low.

Indent (iii) is also fairly self-explanatory, though as indicated before, it is really important to understand what the ‘mobile equipment’ is. An industrial heater or a steam cleaner could be a good example of an appropriate application of a 30 mA RCD on a three-phase 32 A socket. A mobile unit (such as a site office) which has its own distribution inside with final circuits already protected by a 30 mA RCD, is an example of where the designer should consider the application, including the routing and protection of the supply cable. In this case, there is no selectivity between the RCDs in the cabin and a fault or excessive leakage currents could cause power to be lost to the cabin itself, which doesn’t avoid any potential dangers or minimize inconvenience in the event of a fault.

This is explored in Note 2 which is of particular importance here. It refers to regulation 314.1 indent (iv) which is:

Division of Installation
Every installation shall be divided into circuits, as necessary, to:….
(iv) *reduce the possibility of unwanted tripping of RCDs due to excessive protective conductor (PE) currents not due to a fault*

Also of relevance are indents (i) and (iii) of the same –

(i) *avoid danger and minimize inconvenience in the event of a fault*
(iii) *take account of hazards that may arise from the failure of a single circuit such as a lighting circuit*

Note 2 of 411.3.3 references regulation 531.3.2 which reinforces this requirement as follows:

531.3.2 *Unwanted tripping*
Residual current protective devices shall be selected and erected such as to limit the risk of unwanted tripping. The following shall be considered:
subdivision of circuits with individual associated RCDs. RCDs shall be selected and the circuits subdivided in such a way that any earth leakage current likely to occur during normal operation of the connected load will not cause unwanted tripping of the device. See also Section 314.

As regular readers know, it is always good to refer back the fundamental principles in Part 1, from which all other requirements stem. One - often overlooked - requirement is so important in any electrical design:

132 DESIGN

132.1 General
The electrical installation shall be designed by one or more skilled persons to provide for:
the protection of persons, livestock and property in accordance with Section 131
the proper functioning of the electrical installation for the intended use.

'Proper functioning' of course means that the installation will perform as required without protection operating unnecessarily. For example, one wouldn't install a six amp circuit breaker on a domestic cooker supply as it will operate whenever the cooker is turned on. So why fit a 30 mA RCD to a socket-outlet where the leakage currents of connected loads are likely to cause operation of the RCD? A proper consideration of the design, application and a documented risk assessment might well be in order for many designs.

In summary, not all socket-outlets should be protected by a 30 mA RCD. And doing so in some cases can be distinctly unhelpful to users – it may also mean your installation actually *doesn't* comply with the fundamental principles of BS 7671!

DC Realisation in the 21st Century

By: **Steven Devine, with thanks to the IET's 48VDC Realisation Forum**

Part 3 of this series looks at DC Realisation in the 21st Century.

This article is part 3 of a 4-part series taking us through the history of DC evolution to the benefits of modern-day application.

Opportunities and considerations for electricians and EngTechs

New technologies and installation practices result in new work opportunities.

Constant change

With the introduction of new requirements, technologies and installation practices there will always be new streams of work and training available. Many may see this as an obstacle but, in reality, it presents an opportunity for companies to diversify and explore new avenues for business and to embrace greener initiatives for a cleaner future.

The construction industry is one which provides a never-ending stream of opportunities for trades persons of all areas of construction and engineering. In particular with the electrical industry due to all of the new technologies that continue to surge into our world.

Challenges

Of course, this presents its challenges with the need to constantly retrain and learn new skills which puts pressure on training providers and for those who are already working in the industry that need to keep a constant eye on what emerging technologies are on the horizon and the new skills that will be required, so that they can undertake installations and stay in business.

In recent years we have seen an increase in solar PV arrays, battery storage, ground source and air source heat pumps and now we have driving demand for EV charging points across the UK, which is only set to increase with ongoing fuel shortages and increasing cost of fossil fuels.

All of these areas of emerging technology require additional specialised knowledge and skills over and above that of what the current conventional electrical apprenticeship will offer.

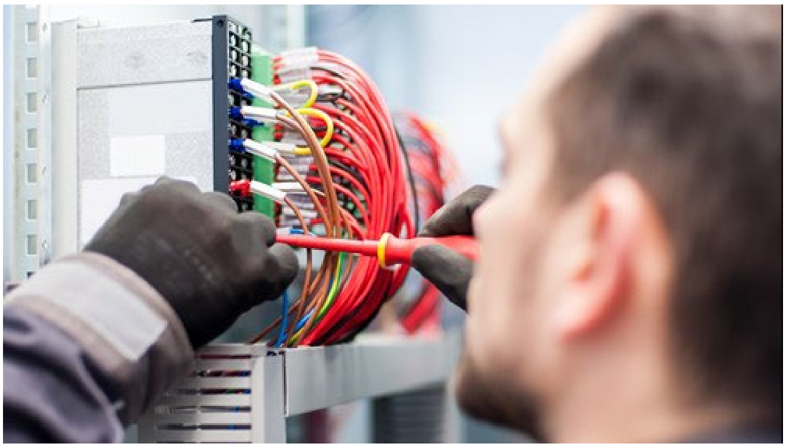
Realisation

It seems logical that local DC distribution will become more popular as the benefits become widely understood. This will subsequently result in increased demand for electrical engineers, electrical designers and electricians who have the required skill set to undertake work on DC distribution systems and DC electrical installations.

Opportunity

What opportunities lie ahead with the advances in localised DC distribution for:

Electricians



DC distribution introduces an opportunity for electricians to explore a new specialism. Utilising DC within an installation to negate the need for multiple points for AC/DC conversion to power devices and equipment has its complexities, and is not covered to a great extent in conventional electrical apprenticeships and equivalent qualifications. By gaining knowledge and understanding in this area, electricians can expand their skill set, become more desirable to employers and familiarise themselves with emerging technologies to maintain a strong position within our industry.

Designers

The design characteristics of systems utilising local DC distribution to circuits have significant differences to that of AC systems. Many considerations must be borne in mind such as, switching and isolation, segregation and identification of circuits, current carrying capacity of conductors, correct selection of devices and equipment, varying voltage ranges for the efficiency and adequacy of installed and portable equipment. For designs which require enhanced energy efficiency and monitoring, utilisation of DC distribution can provide an excellent solution for designers to consider.

Manufacturers

The most significant long-term benefit for manufacturers of equipment that requires DC to function is the reduction of the components that convert AC to DC. Additional power converters for laptops, phones, television, games consoles etc. all add to the cost of design and production. You may have noticed that some popular smartphone manufacturers no longer supply BS 1363 plug-to-USB adapters. This obviously has benefits for the manufacturer with respect to cost, but it also has significant environmental benefits with the reduction of materials required for the components and packaging.

Are manufacturers already anticipating a future where DC outlets are so readily available that it will no longer be required for USB powered devices to be supplied with their own AC/DC adapters?

Recognition

There are various ways that electricians can gain recognition of their competence, qualifications and expertise. With respect to working in the construction industry, there are two common routes that qualified electricians embark on:

- Qualified Supervisor (QS) registration so that an enterprise can work on domestic electrical installations and complete and certify notifiable work in England.
- Electrotechnical Certification Scheme (ECS) card registration so that they can gain access to work on construction sites across England.

Although not very common, professional registration is becoming more popular for electricians across the UK to demonstrate their expertise and competence. For electricians, the most popular is Electrician EngTech.

Other considerations are to register with trade associations such as the ECA and SELECT that will assess qualifications and experience. By registering with a scheme provider or trade association you will increase your status in the industry and for those who are familiar with the trade associations, you will become more desirable as an employee or contractor.

Individual competence

What is often overlooked when seeking out an electrician (from a member of the public perspective) is that when choosing an electrical installer that works for a company (enterprise) that has a registered Qualified Supervisor (QS) with a scheme provider such as NIC EIC or NAPIT, that it is a single person within that company that is registered on behalf of the whole company. The person that comes to carry out the work may not have been assessed and may not have the same qualifications and experience as the QS. However, under the new Electrotechnical Assessment Specification (EAS), employees of an enterprise are expected to undertake regular CPD that is relevant to the work that they will be undertaking and should be competent to carry out such work.

So, how do you identify individual competence? There is no easy way to assess this as much of what is learned in the electrotechnical industry is through experience rather than attending training courses and completing qualifications etc. Individual competence can be demonstrated to some extent by being registered in some way. Typically, the general public will not appreciate the value of an electrician that has their own registration as opposed to working for an enterprise that is registered. However, a simple search on the internet can provide details of the various registration categories and should a diligent customer wish to obtain some information about the registered individual who will be working on their property, there is information available.

So how can the evolution of DC distribution help when it comes to recognition, IET membership application and professional registration?

When applying for IET membership and professional registration you will be assessed in part with respect to your qualifications but will also be asked to demonstrate CPD and provide examples of what you have been doing as an electrician, designer or as an engineer to satisfy the requirements for the various levels of membership and professional registration.

The concept of DC distribution is making a comeback and there are various new technologies that will inevitably result in an increase in demand for skills in these areas. The ability to demonstrate knowledge and expertise in emerging technologies and new concepts will provide fantastic additional content to your portfolio. Therefore, if an individual can build a portfolio of evidence of the work that they have been undertaking, and the various CPD activities that they have attended, it can provide a good foundation for application of professional registration and other forms of registration options.

The following tiers of membership at The IET are as follows:

- Student (including Apprentices)
- Associate
- Member (MIET or TMIET)
- Fellow (FIET)
- Honorary Fellow (HonFIET)

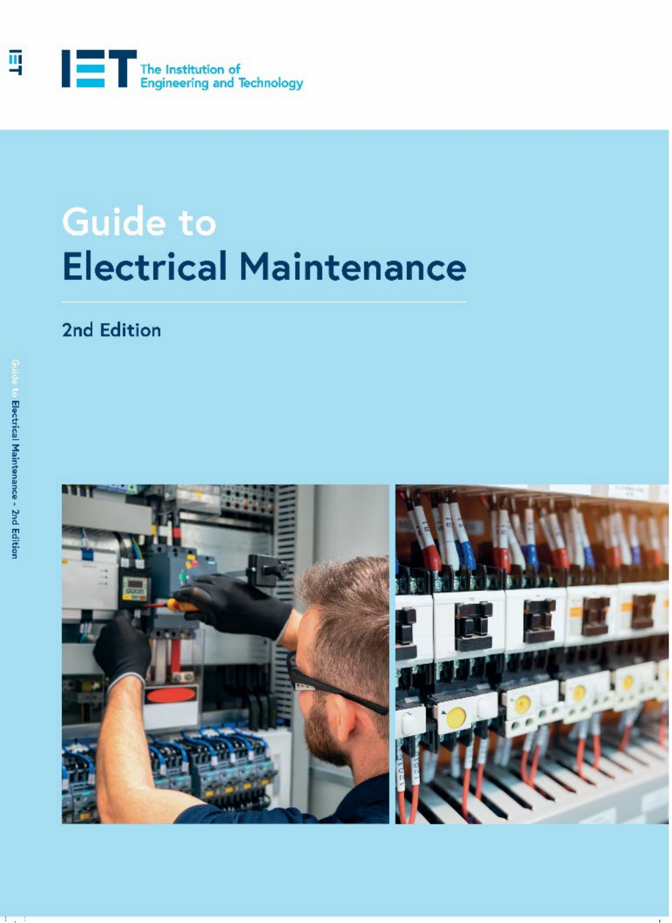
Professional Registration:

- Chartered Engineer (CEng)
- Incorporated Engineer (IEng)
- Engineering Technician (EngTech)
- Electrician EngTech (EngTech)
- ICT Technician (ICTTech)

One of the many benefits of registering with the IET is that when you are assessed, you have to provide a concise history of the knowledge and experience that you have obtained whilst working in your particular area of specialism. Gaining membership with the IET (MIET) is no easy feat and requires the applicant to demonstrate a minimum level of competence in their particular field. To further progress your membership and to gain professional registration is another challenge all together and you will only be accepted if you are in a position to demonstrate your competence and satisfy the assessment panel who will review your application in detail.

The electrotechnical industry is evolving so quickly that even training organisations and standards development committees are working tirelessly to keep pace so that education and requirements are developed to meet industry demand.

Is DC distribution a solution for a more sustainable future?



Electrical maintenance: a framework for good practice

By: **Cameron Steel**

Cameron Steel, Electrical Design Engineer and Associate Director of Silver EMS, writes about the framework for good electrical maintenance.

The background

The first edition of the IET Guide to Electrical Maintenance was published in 2015. It built on the legacy of previous IEE publications that had focused on specific aspects of electrical installation maintenance. About eighteen months ago the editorial committee was reconvened with new members and set to work to evaluate the format and content of the first edition. A partial rewrite and insertion of additional material followed. The revised and updated second edition received close scrutiny and valuable contributions from the editorial committee and from several others who became involved at the DPC stage. It is now ready for publication and relaunch.

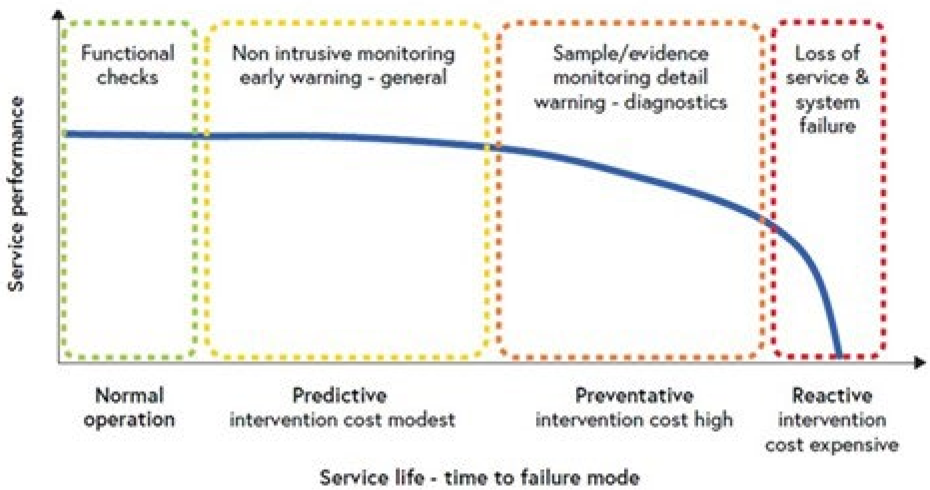
The first edition noted that good maintenance regimes do not happen by accident: they need careful planning, proactive management, and comprehensive reporting. The tone for successful maintenance outcomes and processes should be established beforehand by considerate design, intelligent construction, and satisfactory commissioning. Industry initiatives and programmes such a Soft Landings draw a definitive link between good design, robust construction and successful maintenance across all installations, not just electrical installation. A good design should always consider the installation from various perspectives such as ease of installation, facilitating commissioning and maintenance including decommissioning and replacement.

The maintenance team must be seen as a key stakeholder in consultations during the design and the construction phase of a project. Proper assessment of the connections to the existing infrastructure should be thought through to ensure that the infrastructure can support the new build and can also deal with seasonal demands. Any residual design risks going forward should be noted to allow for future growth and any planning that needs to be assessed. That information will help inform the next project designers.

Robust maintenance regimes do not just start with a project handover. They should start far earlier. Project handover, with a comprehensive and site-specific Operation and Maintenance (O&M) Manual, should indicate that correctly managed and documented maintenance practices have already commenced. The only maintenance management process left to start should be regular auditing and any consequent replacement of expired equipment.

Understanding the strategies for maintenance and knowing when to use them is a responsibility for maintenance managers and technicians alike. Different responses will be required for preventative, reactive or predictive maintenance. Relative costs will also influence the required maintenance strategy. Electrical equipment has become increasingly more efficient and better controlled, but it all has a limited lifespan. Maintenance is a necessity, not an inconvenient overhead and the associated costs can be influenced by good design and by maintenance strategy management.

Figure 1 The relative cost of maintenance intervention



It has to be recognised that robust electrical maintenance regimes have a significant role in a more sustainable world where electrified heat, low carbon technologies and on-site electrical generation are now mainstream installations. Modern electrical installation designs are using technologies that consume less energy during their lifespan, but only if they are looked after properly. Correctly maintained electrical systems will keep operating at optimum energy efficiency for far longer, help reduce energy consumption and minimise carbon emissions.

Energy costs have been trending upwards for many years and has accelerated recently. The financial imperative of a well maintained, low energy electrical installation needs to be correctly appreciated by the business manager – otherwise poor maintenance will undermine the bottom line.

The second edition provides updates to the original text and introduces additional items and areas for consideration as part of a maintenance programme. It also redefines the guide as a reference document for both the management of electrical maintenance and also the practicalities of electrical maintenance activities across a range of activities.

The original management related sections of the 1st edition are now part of a new main Section 1 which focuses on the administration and policy of maintenance with additional content and diagrams.

A refreshed framework

Appendix B of the 1st edition now forms a new Section 2 of this refreshed publication. It provides a greater focus on the practical aspects across a wide range of electrical installations. Additional topics are added such as heat pumps and electric vehicle charge points.

Section 2 looks at specific electrical maintenance tasks in a number of areas from a risk assessment approach that is based around the format suggested in BSRIA BG53 *Business-Focused Maintenance.*

The BG53 format has been adapted to appraise various electrical systems and inform on the urgency of some maintenance tasks over others to make it a more practical tool for technicians and supervisors alike. By following the process, it can be used as a framework for other site-specific tasks not covered in this edition. It provides a mechanism that supports careful assessment of engineering systems to ensure continued health and safety, business continuity and comfort of occupants. The premise is that this method can be adapted and further developed by the reader over a number of other electrical systems specific to their particular electrical installation and not just focus on buildings.

Section 2 focuses on four key areas of electrical maintenance: Energy input to electrical systems, general applications and circuit protection, life safety systems and also industrial equipment and associated control systems.

The beginning of each key area provides a table that examines critical issues such as health and safety, business criticality and occupant comfort. The significance of failure is examined and sets the context for maintenance of these electrical systems. Further issues such as client image and status, asset life and environment and sustainability can also be assessed in the same critical issues analysis.

Figure 2 Generic critical issues examples

Criticality issue as identified in BSRIA BG53	Significance of failure Commentary on generic risks for electrical maintenance
Health and safety and legislation	The significance of this could be described as high when the electrical system has a major impact on health and safety, or continued operation of the electrical system is a legislative compliance issue.
Business criticality	Is the electrical system critical for business continuity? This could be highly significant if it relates to data centres, factory production or finance services. However, other contexts should also be explored. Loss of electrical supplies to other utility services, such as water, will impact on public health or the environment. In some installations, such as healthcare, the focus on business criticality will be on continuity of care, even in non-urgent situations. Other installations in the public sector will also have their own requirements regarding business criticality.
Occupant comfort	Is the loss of electrical system likely to make an environment uncomfortable for the user? For instance, this could be highly significant if electrical supplies fail to ventilation systems or electrical heating. Long term failure of electrical water heating could lead to secondary issues with water borne diseases. The loss of a few external lights could be seen as a low significance, especially if there are other lights around and the installation is typically only used during the daytime.

Detailed focus on a number of topics looks at task specific risks and their mitigating actions. The tables look at specific maintenance risks on different parts of the electrical installation and evaluates failure modes, consequence of failure, preventative action and advises on frequency of activity. A total of 31 electrical maintenance topics are covered in Section 2 based around the four key areas outlined above. The layout and format of these tables allows the reader to add further site-specific topics and evaluate the related tasks in easy steps.

Figure 3 Task specific risks and mitigating actions

Component	The failure mode addressed and its cause or other reason for maintenance	Consequence of failure	Preventative action	Generic frequency
The electrical system	What has happened and the effect on a space or occupants?	What is the net effect of the failure?	What activities are required to prevent the failure or reduce the impact of failure?	How often such preventative checks should be carried out?

Electrical maintenance places specific legislative and regulatory responsibilities on the occupier of a building and associated premises as duty-holders to ensure the continued safety of electrical installations. The new Building Safety Act 2022 could add to these duties. There are already statutory obligations to ensure the successful operation of life safety systems, such as emergency lighting and fire detection and alarm systems, when they are actually needed. The maintenance of such systems and the associated audit trail in high-risk buildings, for instance, will become more important.

Transportation systems such as lifts, escalators and moving walkways also need periodic assessment. Insurance policies may be an additional driver of this – if periodic certification cannot be produced then insurance policies may not be honoured if the need arises.

BS 7671 (the IET Wiring Regulations) and the accompanying Guidance Notes discuss the periodic testing and inspection that should be at the heart of any maintenance regime for the premises’ electrical installation.

Maintenance activity, especially on life safety systems, needs to be recorded and signed off. To demonstrate compliance of fire alarms, emergency lighting and similar systems with statutory requirements a logbook recording periodic tests should be used. This, in turn, must be left available for auditing purposes. Dates of test, anomalies, and remedial actions should all be noted.

Exit strategy

We should all be considering our impact on the planet. Within the electrical industry many of the materials we use should be assessed for reuse or safe disposal. The final obligation of the maintainer is to ensure that all time-expired equipment is disposed of correctly at the end of its lifecycle. Regulations need to be considered here too as most electrical and electronic equipment at the end of their useful life will be covered by the Waste Electrical and Electronic Equipment Directive.

Summary

There is a lot more to electrical maintenance than just turning up with a toolbox and pack of lamps or a replacement faceplate. You should not run your car without an annual MOT and regular servicing of the vehicle is advisable. Do not neglect your electrical installation either.

Make sure you understand how to maintain under a safe system of work and how to reinstate carefully. Evaluate the maintenance risks to the maintainer and the end user of the installations. Monitor costs, evaluate maintenance strategy and make informed decisions on when to intervene and ensure continuity of service.

Guide to Electrical Maintenance, 2nd Edition

https://shop.theiet.org/electricalmaintenance

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Changes to RCD testing in BS 7671:2018+A2:2022

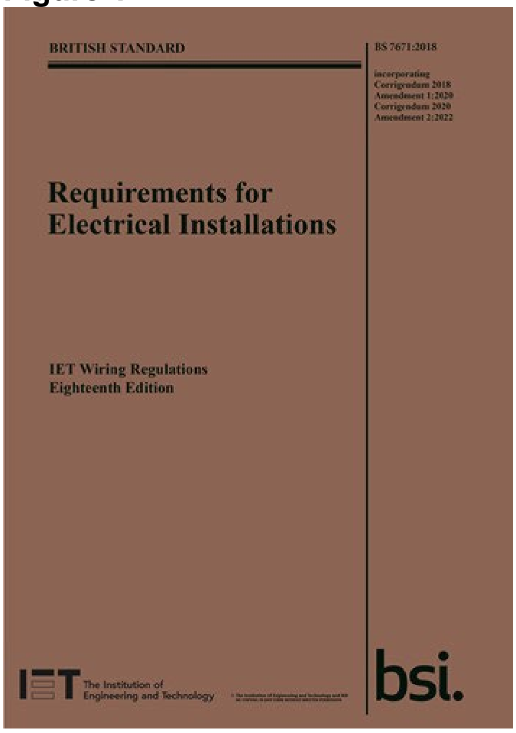
By: **Michael Peace CEng MIET**

This article focuses on the changes introduced in Amendment 2 to BS 7671:2018 in respect to testing of RCDs (RCCBs & RCBOs as they are more commonly known), it also addresses a number of common questions relating to RCD technology

The early style Residual Current Devices (RCDs) were highly effective protective devices but they have proven to be less reliable in modern buildings as a consequence of DC leakage and DC fault currents caused by electronic equipment. Subsequently, new types of RCD have been developed.

This article focuses on the changes introduced in Amendment 2 to BS 7671:2018 in respect to testing of RCDs (RCCBs & RCBOs as they are more commonly known), it also addresses a number of common questions relating to RCD technology. For further information on the different RCD Types and the selection process, see IET Wiring Matters article (Issue 77 September 2019), 'Which RCD Type?'.

Figure 1



Brief history of RCDs

As with most inventions, RCDs were developed by different people. Dr Gottfried Biegelmeier (1924-2007) was an Austrian Physicist who filed a patent for the first residual current circuit-breaker (RCCB) in 1957. When RCDs were first developed, little was known about the effects of electric shock in human beings and, of course, the devices needed to be proved to work. As a result, Dr Biegelmeier carried out many of his experiments on himself, the results of which went into IEC report #479 (as it was known) but has since become IEC 60479 *effects of current on human beings and livestock*. For further information see, GOTTFRIED BIEGELMEIER, an oral history conducted in 1996 by David Morton, IEEE History Center, Piscataway, NJ, USA.

What are the changes to the requirements for selection of RCD Types?

Before we look at testing RCDs, it is worth pointing out that the requirements for selection and erection of RCDs have been amended. Regulation 531.3.3 of BS 7671:2018+A2:2022 states that the appropriate RCD shall be selected according to the presence of DC components and AC frequencies. Further, Type AC RCDs shall only be used to serve fixed equipment, where it is known that the load current contains no DC components.

Type AC RCDs are affected by residual DC components and can become desensitized or 'blinded' and may not operate within the required time or, in some instances, may not operate at all. Table 1 summarizes the various types of RCD referred in BS 7671:2018+A2:2022 and their resilience to DC components.

Given the prevalence of electronic equipment in most installations, it is difficult to see how the electrical designer will be able to justify the use of Type AC RCDs. Many manufacturers have discontinued Type AC RCDs, preferring to supply type A as a minimum. Therefore, in future it is possible that Type AC RCDs will become obsolete due to lack of demand and Type A RCDs will become the common choice for most new installations, so it is important to understand the changes to the requirements for RCD testing.

For further information on the different RCD Types and the selection process, see IET Wiring Matters article (Issue 77 September 2019), 'Which RCD Type?'
Table 1 Summary of RCD types

	Residual / Leakage current components			
RCCB Type	AC 50 Hz	AC 50 Hz	Smooth DC	AC>50Hz<kHz
AC	✓	✗	✗	✗
A	✓	✓	< 6 mA[1]	✗
F	✓	✓	< 10 mA[1]	✓
B	✓	✓	✓[1]	✓

(1) **Type B** RCCBs detect DC residual currents and trip if the smooth DC current exceeds the trip threshold.
Note: Type A and **Type F** will function safely with smooth DC residual currents present up to the levels indicated but they do not detect smooth DC. Therefore, they must not be installed upstream of Type B RCCBs.

Why are changes to the requirements for RCD testing necessary?

Sub Committee A of JPEL/64 scrutinized the product standards for RCDs and noted the complexity of testing parameters, as well as the results permitted by the standards that could be used to prove the functionality of an RCD when bench tested in a laboratory.

It was noted that those testing RCDs in the field would find it difficult to carry out the variety of tests permitted and may not know which of the available tests would be applicable to a given make or type of RCD.

It was therefore agreed that the testing procedure could be greatly simplified and safety would remain unaffected since RCDs are, in any event, tested extensively by manufacturers prior to sale.

What are the changes to the requirements for RCD testing?

The good news is that the changes do not require you to purchase a new test instrument. In BS 7671:2018 the time/current performance criteria for RCDs to BS EN 61008-1 and BS EN 61009-1 were included in Table 3A of Appendix 3 as shown in Table 2. This has been deleted by BS 7671:2018+A2:2022.

Table 2 Table 3A from BS 7671:2018 - DELETED BY Amendment 2

TABLE 3A – Time/current performance criteria for RCDs to BS EN 61008-1 and BS EN 61009-1

RCD type	Rated residual operating current $I_{\Delta n}$ mA	Residual current mA	Trip time ms	Residual current mA	Trip time ms	Residual current mA	Trip time ms
General Non-delay	10	10	300 max.	20	150 max.	50	40 max.
	30	30		60		150	
	100	100		200		500	
	300	300		600		1500	
	500	500		1000		2500	
Delay 'S'	100	100	130 min. 500 max.	200	60 min. 200 max.	500	40 min. 150 max.
	300	300		600		1500	
	500	500		1000		2500	

The requirements for RCD testing in BS 7671:2018+A2:2022 are given in the notes to Regulation 643.7.1 for fault protection and Regulation 643.8 for additional protection. A note in each section states the requirements and the key points are highlighted below.

Regardless of RCD type, e.g. AC, A, F or B, an alternating current test shall be used at the rated residual operating current ($I_{\Delta n}$), with a maximum operating time not exceeding 300 ms for general non-delay type RCDs.

For 'S' Type time-delayed RCDs, the operating time shall be between 130 ms (minimum) and 500 ms (maximum). S Type time-delayed RCDs are not applicable for additional protection, hence, the operating times are not included in Regulation 643.8.

There is no longer a requirement to perform a test using a test current equal to or higher than five times the rated residual current.

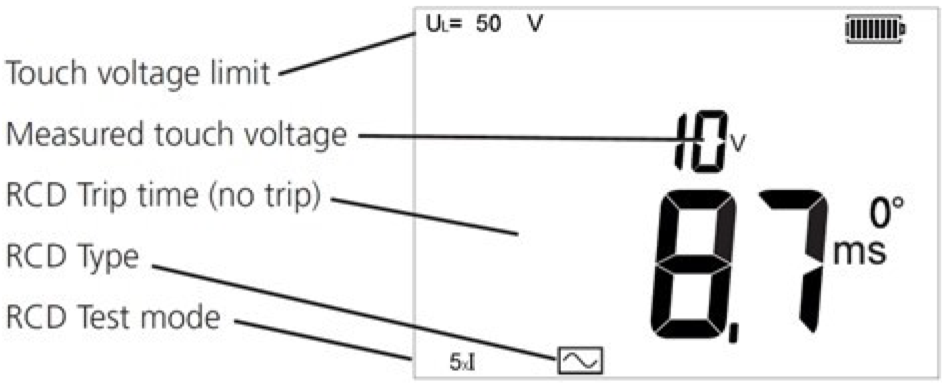
What is an alternating current test?

The type of test is selected on the instrument according to the RCD type. When the instrument setting selected is for an AC Type RCD, the test current applied is a 50 Hz alternating current. However, when the instrument setting selected is an A Type RCD, a pulsed direct current (DC) is superimposed on the 50 Hz AC waveform.

Whilst some testers are capable of testing different types of RCD with a variety of fault currents, BS 7671:2018+A2:2022 only requires an AC test to show compliance. This means that the test instrument needs to be set to the Type AC RCD setting regardless of RCD Type.

Each manufacturer’s instrument is different but changing the RCD Type is usually selected by pressing the relevant ‘function’ button on the instrument and the RCD Type symbol will change accordingly: see Figure 2. Most instruments will include a function to test general non-delayed and S Type time-delayed Type AC and Type A RCDs, some test instruments may also include a facility for testing other Types such as Type B RCDs.

Figure 2 Example, test instrument display screen



What is the maximum disconnection time for TT earthing systems using an RCD for fault protection?

Given that an RCD may take up to 0.3 seconds (300 ms) to disconnect it would appear at first glance that some disconnection times in Table 41.1 may not be achievable, for example, the maximum disconnection time for some final circuits on a TT earthing system is 0.2 seconds (200 ms), as shown in Table 3. However, a note under the table indicates that earth faults are of negligible impedance and it follows that disconnection times would be commensurately higher since a value of, for example, a residual current of 60 mA would be expected to provide a disconnection time of 150 ms and 40 ms (0.04 seconds) for a residual current of 150 mA, as shown in Table 2. Therefore, an operating time of 300 ms would be considered acceptable for a TT earthing system.

Table 3 Table 41.1 BS 7671:2018+A2:2022

TABLE 41.1 –
Maximum disconnection times

System	$50\ V < U_0 \leq 120\ V$ (s)		$120\ V < U_0 \leq 230\ V$ (s)		$230\ V < U_0 \leq 400\ V$ (s)		$U_0 > 400\ V$ (s)	
	AC	DC	AC	DC	AC	DC	AC	DC
TN	0.8	NOTE 1	0.4	1	0.2	0.4	0.1	0.1
TT	0.3	NOTE 1	0.2	0.4	0.07	0.2	0.04	0.1

Where in TT systems the disconnection is achieved by an overcurrent protective device and the protective equipotential bonding is connected with all extraneous-conductive-parts within the installation in accordance with Regulation 411.3.1.2, the maximum disconnection times applicable to TN systems may be used.

U_0 nominal AC rms or ripple-free DC line voltage to Earth.

Where compliance with this regulation is provided by an RCD, the disconnection times in accordance with Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD.

Can other types of RCD testing be carried out?

Some will argue that in order to verify if an RCD will operate correctly in the presence of DC components, using the appropriate DC test instrument setting for the RCD Type must be carried out in addition to testing using the AC type setting.

Generally, an RCD either works or it doesn't and, in essence, the test is to prove that the RCD is functional and is not intended to confirm that it still performs as per the relevant product standards and manufacturers requirements. RCD testing required by product standards is carried out by the manufacturer and is called type testing.

Whilst BS 7671:2018+A2:2022 doesn't require other types of RCD testing, however additional tests are not precluded and may be useful for fault finding purposes, these tests could include:

- ½ x $I_{\Delta n}$ test
- 5 x $I_{\Delta n}$ test
- RCD type (AC, A, B, F)
- RCD tripping current (ramp test)
- Phase angle (0° & 180°)

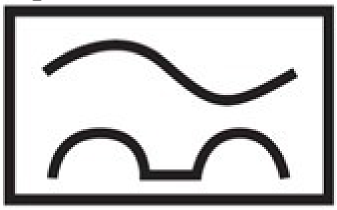
However, if you do choose to carry out additional testing, it is important to understand how the instrument operates when using different test settings for the various RCD types. It is also important to understand what results to expect according to product standard requirements.

Further information on RCD operating and non-operating times can be found in the relevant product standards. Type A and Type AC RCCBs and RCBOs are manufactured to BS EN 61008 and BS EN 61009 respectively, whereas Type F and Type B RCCBs and RCBOs are manufactured to BS EN 62423.

RCD testers are designed and manufactured to BS EN 61557-6 *Effectiveness of residual current devices (RCD) in TT, TN and IT systems* for testing electrical installations. The standard requires that the instrument be able to verify correct disconnection of the supply in the event of a fault but it does not provide requirements for extensive product standard testing. Subsequently, not all instruments will be well suited to carrying out anything more than the most rudimentary of tests.

What are the different characteristics of the Type A setting on the test instrument?

Figure 3



Now that we have strayed away from using AC tests, things start to get more complicated and further knowledge both of the limitations and configuration of the instrument you are using and relevant product standards is needed, in order to verify the results.

When the Type A setting is selected on the instrument, a half wave pulsating residual test current superimposed on a smooth direct current of 6 mA is produced, which effectively applies a 1.4 multiplier to the rated residual current ($I_{\Delta n}$). For example, if the 30 mA setting is selected, the RCD will be subjected to a test current of 42 mA (30 x 1.4 = 42 mA).
Similarly, for instruments with a setting for Type B RCDs a multiplier of two times $I_{\Delta n}$ is applied as required by the product standard, BS EN 62423:2012 *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses.*
This is where knowledge of relevant product standards is essential, it would be reasonable to expect a 40 ms maximum disconnection time for a test at five times $I_{\Delta n}$ as would be the case with an AC test. However, this is not the case as the product standard BS EN 61008 requires a half wave pulsating residual current of 0.35 A (350 mA), see Table 4 extracted from BS EN 61008-1:2012+A2:23-1:2012+A11:2015.
If the Type A RCD setting is selected on the test instrument, the test current is increased by a factor of 1.4. Therefore, if the instrument is set to perform a test on a 30 mA RCD at five times $I_{\Delta n}$, a test current of 210 mA (30 x 5 x 1.4 = 210 mA) would be produced which may not be sufficient to operate the RCD within the required time as the product standard requires a test current of 350 mA (0.35 A), as described previously.
Some test instruments have a variable trip current setting, if a tripping current of 50 mA at five times $I_{\Delta n}$ was selected on the Type A setting, a trip current of 350 mA could be simulated (50 x 5 x 1.4 = 350 mA). However, the variable test current feature is not available on all test instruments.

Table 4 Maximum values of break time for Type A RCD extracted from BS EN 61008-1:2012+A2:23-1:2012+A11:2015

			Maximum values of break time(s) for type A RCCB in event of half-wave pulsating residual currents (rms values) equal to							
Type	I_n A	$I_{\Delta n}$ A	1,4 $I_{\Delta n}$	2 $I_{\Delta n}$	2,8 $I_{\Delta n}$	4 $I_{\Delta n}$	7 $I_{\Delta n}$	0,35 A	0,5 A	350 A
General	Any	< 0,03		0,3		0,15			0,04	0,04
		0,03	0,3		0,15			0,04		0,04
		> 0,03	0,3		0,15		0,04			0,04
S	≥ 25	> 0,03	0,5		0,2		0,15			0,15

What is the expected endurance of an RCD?

All mechanical or electrical equipment has a finite lifespan. For RCDs, part of the product standard test procedure is to ensure a minimum number of operating cycles. BS EN 61008 requires RCDs having $I_{\Delta n}$ > 10 mA are subjected to 2000 operating cycles, each operating cycle consisting of a closing operation followed by an opening operation. This is a combination of manual operation, using the test button and using a test current of $I_{\Delta n}$.

For those that decide to continue to carry out all of the tests previously required, it is important to consider what the benefits really are and if the lifespan of the RCD be reduced, possibly to the point where it may not work when required.

RCD testing issues

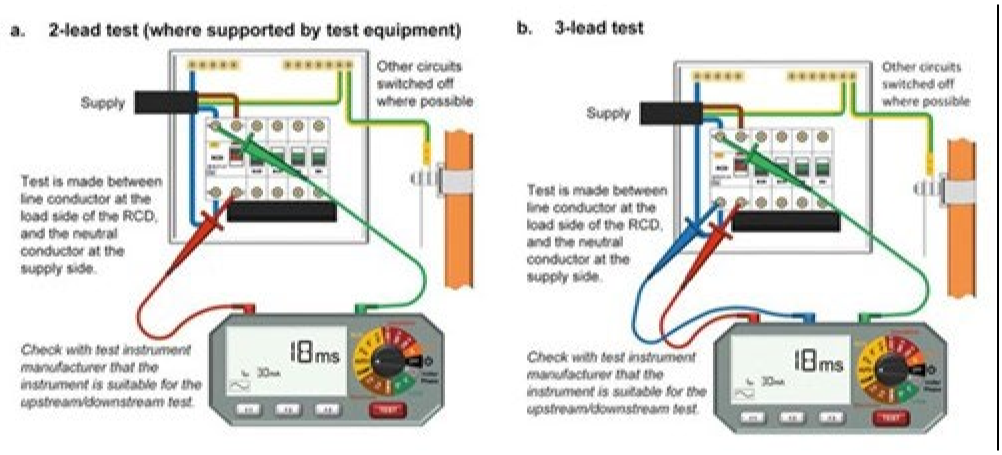
Many of the issues encountered when testing RCDs are down to user error as opposed to faulty RCDs. It may come as a surprise to some, but RCD testing should be carried out at the RCD with the outgoing wiring disconnected. However, this is not usually done. The usual live working procedures must be considered, and suitable precautions taken when carrying out work near live parts.

RCD tests may be affected by loads downstream that contain electronic equipment or may incorporate permanent leakage current due to the capacitance of cables where circuit lengths are considerable.

An RCD test instrument operates by applying a fault current and recording how long it takes the RCD to disconnect the supply. Where circuits comprise capacitance due to connected loads or due to long cable lengths, even after the RCD has operated, the capacitance in the circuit will continue to discharge influencing the result recorded by the instrument.

Further information on RCD testing can be found in IET Guidance Note 3 *Inspection and Testing* and PD IEC TR 62350:2006 *Guidance for the correct use of residual current-operated protective devices (RCDs) for household and similar use* which states that 'The testing current should be applied between the upstream and downstream terminal of the RCD', see Figure 4 extracted from IET Guidance Note 3 *Inspection and Testing*.

Figure 4 RCD testing arrangements taken from IET Guidance Note 3 Inspection & Testing



Cascaded RCDs for selectivity

In addition, cascaded RCDs are sometimes provided to meet selectivity requirements. A common example is RCDs with residual current rating not exceeding 30 mA in a caravan, required by Regulation 721.415.1 of BS 7671, supplied by a socket-outlet or pitch-outlet, which itself is required to be protected by an RCD with residual current rating not exceeding 30 mA by either Regulation 411.3.3 or 708.415.1 of BS 7671:2018+A2:2022. When the downstream RCD is tested, the upstream RCD may operate; there are methods available to address this when testing. For further information, see IET Guidance Note 3 *Inspection and Testing.*

Summary

The days of selecting an RCD according to current rating and rated residual current alone are gone, now the designer must select the RCD according to the nature of the residual fault currents, including pulsed or steady-state DC components expected to be present.

The requirements for testing RCDs have been simplified, a single test is all that is required to show compliance with the minimum requirement laid out in BS 7671:2018+A2:2022. Regardless of RCD type, the test is carried out using an alternating test current, applied at the RCD's rated residual operating current $I_{\Delta n}$, the maximum disconnection time is expected to be less than 300ms for a general non-delay type RCD. For S type time-delayed RCDs, the operating time should be 130 - 500 ms. Other kinds of RCD testing may be useful for fault finding purposes.

It is important to note that a test at both 0 and 180 degrees is not required.

It is essential to understand the limitations of the test instrument and product standard requirements when testing RCDs using the available RCD Type settings on the test instrument.

If you think you may have a faulty RCD, firstly ensure there are no factors within the installation that are influencing the results. Always carry out RCD testing in accordance with industry guidance and manufacturer's instructions.

Finally, remember an RCD has a finite lifespan, so, give consideration to whether or not extensive testing is beneficial or may have the opposite effect.

Further reading

IET Wiring Matters article, 'Which RCD Type?'
Eaton RCD application guide
BEAMA RCD handbook
IET Guidance Note 3 *Inspection and testing*
BS 7671:2018+A2:2022 *Requirements for Electrical Installations, IET Wiring Regulations, 18th Edition.*
PD IEC/TR 62350:2006 *Guidance for the correct use of residual current-operated protective devices (RCDs) for household and similar use.*
BS EN 61008-1:2012+A12:2017 *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs). General rules.*
BS EN 61009-1:2012+A13:2021 *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs). General rules.*
BS EN 62423:2012+A11:2021 *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses.*
BS EN IEC 61557-6:2021 *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. Equipment for testing, measuring or monitoring of protective measures. Effectiveness of residual current devices (RCD) in TT, TN and IT system.*
IEC 60479 series *Effects of current on human beings and livestock*
GOTTFRIED BIEGELMEIER, an oral history conducted in 1996 by David Morton, IEEE History Center, Piscataway, NJ, USA.

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